MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2015/2016

EME4096 - INTERNAL COMBUSTION ENGINES

(ME)

02 JUNE 2016
2:30 p.m – 4:30 p.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 5 pages including cover page and appendices with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

A four cylinder, 2.5-liter engine operates on a four-stroke cycle at 3600 RPM. The compression ratio is 9.6:1, the connecting rod length is 20 cm, and the bore and stroke of the engine are related as S = 1.08B. The engine is running with an air-fuel ratio of 16, a fuel heating value of 44,000 kJ/kg, a mechanical efficiency of 85% and a combustion efficiency of 97%. At standard conditions, the density of air is 1.181 kg/m^3.

Calculate:

a) bore and stroke length, [cm], [4 marks]
b) average piston speed, [m/s], [2 marks]
c) distance the piston has travelled from TDC at the end of combustion at 20° aTDC, [cm], [5 marks]
d) the rate of fuel flow into the engine, given that the mass of air enters the cylinders is 0.00048 kg, [kg/sec], [5 marks]
e) brake thermal efficiency, given that the brake power is 68.5 kW, [%], [3 marks]
f) Indicated thermal efficiency, [%], [2 marks]
g) Volumetric efficiency, [%], and [2 marks]
h) Brake specific fuel consumption, [gm/kW-hr]. [2 marks]

Question 2

A six-cylinder, 3.0-liter compression ignition engine using light diesel fuel with fuel heating value of 42,500 kJ/kg at an air-fuel ratio of 20, operates on an air-standard Dual cycle. Half the fuel can be considered burned at constant volume, and half at constant pressure with combustion efficiency of 98%. The cylinder conditions at the start of compression are 55 °C and 100 kPa. Compression ratio is 14:1. Take c_p = 1.108 kJ/kg-K; c_v = 0.821 kJ/kg-K; $k = c_p / c_v$; $R = c_p - c_v$.

Calculate:

a) temperature and pressure at each state of the cycle, [°C, kPa], [13 marks]
b) cutoff ratio, [2 marks]
c) pressure ratio, [2 marks]
d) indicated thermal efficiency, [%], and [3 marks]
e) net indicated work, [kJ/kg]. [5 marks]

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Question 3

i) A 6.0-liter, eight-cylinder, four-stroke cycle SI race car engine operates at 6000 RPM using stoichiometric nitromethane as fuel (A/F = 1.7). Combustion efficiency is 99%, and the mass fuel input rate is 0.198 kg/sec. Assume the density of air is 1.181 kg/m^3. Calculate:

a) volumetric efficiency of the engine, [%], [3 marks]
b) flow rate of air into the engine, [kg/sec], [1 mark]
c) heat generated in each cylinder per cycle, [kJ], and [4 marks]
d) how much chemical energy there is in unburned fuel in the exhaust, [kW]. [4 marks]

ii) A 6.2-liter, V8, four-stroke cycle SI engine is designed to have a maximum speed of 6500 RPM. At this speed, volumetric efficiency is 88%. The engine is equipped with a four-barrel carburetor, each barrel having a discharge coefficient of C_{Dt} = 0.95. The fuel used is gasoline at AF = 15.1 (density of gasoline ρ_g = 750 kg/m^3 and density of air ρ_a = 1.181 kg/m^3). Calculate:

a) minimum throat diameter needed in each carburetor venturi, [cm], and [6 marks]
b) fuel capillary tube diameter needed for each venturi throat if tube discharge coefficient C_{Dt} = 0.85 and the capillary tube height differential is small, [mm]. [7 marks]

Question 4

The divided combustion chamber of a 2.0-liter, four-cylinder, lean-burn, stratified charge SI engine have 22% of clearance volume in the secondary chamber of each cylinder. The intake system delivers an air-gasoline mixture into the secondary chamber at an equivalence ratio of 1.2 and into the main chamber at an equivalence ratio of 0.75. The engine has a volumetric efficiency of 93%, overall combustion efficiency of 99%, indicated thermal efficiency of 52%, and a mechanical efficiency of 86% when operating at 3500 RPM. Assume the density of air is 1.181 kg/m^3. Calculate:

a) overall air-fuel ratio, [8 marks]
b) overall equivalence ratio, [1 mark]
c) brake power at this condition, [kW], [8 marks]
d) bmep, [kPa], [2 marks]
e) amount of unburned fuel exhausted from the engine, [kg/hr], and [3 marks]
f) bsfc, [gm/kW-hr]. [3 marks]

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Appendices

Table 1: Molecular Weights

SUBSTANCE		MOLECULAR WEIGHT (kg/kgmole) or (lbm/lbmmole)
Air		28.97
Argon	Ar	39.95
Carbon	C	12.01
Carbon monoxide	CO	28.01
Carbon dioxide	CO_2	44.01
Hydrogen	H_2	2.02
Water vapor	H_2O	18.02
Helium	He	4.00
Nitrogen	N_2	28.01

Table 2: Properties of Fuels

Fuel		Molecular weight	Heating Value		Stoichiometric		Octane Number		Heat of Vaporization (kJ/kg)	Cetane Number
			HHV (kJ/kg)	LHV (kJ/kg)	(AF)s	(FA)s	MON	RON		
Gasoline	C_8H_{15}	111	47300	43000	14.6	0.068	80-91	92-99	307	40-55
Light diesel	$C_{12.3}H_{22.2}$	170	44800	42500	14.5	0.069			270	35-50
Heavy diesel	$C_{14.6}H_{24.8}$	200	43800	41400	14.5	0.069			230	
Isooctane	C_8H_{18}	114	47810	44300	15.1	0.066	100	100	290	
Methanol	CH_3OH	32	22540	20050	6.5	0.155	92	106	1147	
Ethanol	C_2H_5OH	46	29710	26950	9.0	0.111	89	107	873	
Methane	CH_4	16	55260	49770	17.2	0.058	120	120	509	
Propane	C_3H_8	44	50180	46190	15.7	0.064	97	112	426	
Nitromethane	CH_3NO_2	61	12000	10920	1.7	0.588			623	
Heptane	C_7H_{16}	100	48070	44560	15.2	0.066	0	0	316	
Cetane	$C_{16}H_{34}$	226	47280	43980	15.0	0.066			292	100
Heptamethylnonane	$C_{12}H_{34}$	178			15.9	0.063				15
α-methylnaphthalene	$C_{11}H_{10}$	142			13.1	0.076				0
Carbon monoxide	CO	28	10100	10100	2.5	0.405				
Coal (carbon)	C	12	33800	33800	11.5	0.087				
Butene-1	C_4H_8	56	48210	45040	14.8	0.068	80	99	390	
Triptane	C_7H_{16}	100	47950	44440	15.2	0.066	101	112	288	
Isodecane	$C_{10}H_{22}$	142	47590	44200	15.1	0.066	92	113		
Toluene	C_7H_8	92	42500	40600	13.5	0.074	109	120	412	
Hydrogen	H_2	2	141800	120000	34.5	0.029		90		

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Table 3: Thermodynamic Properties of Air

Temperature		c_p	c_v	$k = c_p/c_v$	Gas Constant $R = c_p - c_v$
K	°C	(kJ/kg-K)	(kJ/kg-K)		(kJ/kg-K)
273	0	1.004	0.717	1.40	0.287
298	25	1.005	0.718	1.40	0.287
300	27	1.005	0.718	1.40	0.287
500	227	1.029	0.742	1.39	0.287
850	577	1.108	0.821	1.35	0.287
1000	727	1.140	0.853	1.34	0.287
1500	1227	1.210	0.923	1.31	0.287
2000	1727	1.249	0.962	1.30	0.287
2500	2227	1.274	0.987	1.29	0.287
3000	2727	1.291	1.004	1.29	0.287

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